USE OF MODELLING TOOLS TO DELIVER A SUSTAINABLE TRANSPORT SYSTEM

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1. INTRODUCTION

The Department for Transport in the UK conducted a review of its appraisal process (NATA) during 2007/8 and concluded that there was a need to reduce the effort required in modelling and appraisal of strategies in the early stage of policy design. The review suggested that one approach may be to conduct a staged appraisal with an initial filtering of options based on easily available qualitative and quantitative information. This could be in the form of a Multi-Criteria Analysis (MCA) and that the indicators should be in line with their parallel guidelines on Delivering a Sustainable Transportation System (DaSTS).

This paper reports on the enhancements made to the strategic model MARS (Mobility Activity Relocation Simulator) which is a fast running Land Use Transport Interaction (LUTI) model capable of simulating policy over an urban region in less than one minute. Three enhancements are described (i) an automated link has been developed between the traffic assignment model SATURN and MARS which means the MARS speed-flow relationships are now compatible with existing network models and that growth factors from a MARS policy run in a future year may be passed back to the more detailed model; (ii) the MCA in line with the DaSTS challenges or goals has been implemented within the software platform (iii) the interface has been upgraded to include spatial policy variables allowing corridor based policies to be analysed.

The model is then applied to three examples – the first demonstrates the use of the MCA with a simple strategy aimed at reducing car use and increasing public transport patronage, the second extends the example to include a value for money indicator (€/ton CO_2 reduced) and applies the VENSIM®[1] optimisation facilities to maximise the weighted MCA, the third demonstrates the use of spatial policy inputs when applied to a Trolley Bus Scheme for corridors in Leeds in the UK.

[1] VENSIM is a software platform for developing system dynamics models.

The work comprised of four main tasks

1. A workshop to gain feedback from local authority representatives on the potential use and developments envisaged for MARS.
2. To provide a link from SATURN to MARS
3. Enhancing the optimisation and strategic appraisal capabilities of MARS
4. To enable policy instruments to be applied to corridors

The first task was covered by a workshop held in Leeds in March 2009. The workshop attracted nine representatives and useful feedback on the development of subsequent tasks was gathered. In particular the representatives were keen to see a fast approach to the filtering or generation of options capable of being developed with limited resources. They appreciated the coarse nature of the model yet were interested in the potential to link with models such as SATURN and in the development of indicators in line with TASTS requirements. A particular merit was thought to be the optimisation capabilities either in finding a set of policies which maximise of a pre-defined objective function or in finding policies which attempt to fulfil the national CO_2 targets (or local targets) over the planning period.

The rest of the paper is structured as follows, the next section gives some background to the MARS model, section three reports on the links between SATURN and MARS, section four describes the development of the appraisal process and gives and example of the optimisation facilities in VENSIM, section five describes the enhancements made to the user interface to enable the introduction of spatial policies while section six summarises and looks to the future.

2. THE MARS MODEL

MARS is a dynamic Land Use and Transport Integrated model. The basic underlying hypothesis of MARS is that settlements and activities within them are self organising systems. MARS is based on the principles of systems dynamics (Sterman 2000) and synergetics (Haken 1983). The development of MARS started some 10 years ago partly funded by a series of EU-research projects. To date MARS has been applied to ten European cities (Bari, Edinburgh, Gateshead, Helsinki, Leeds, Madrid, Oslo, Stockholm, Trondheim and Vienna) and three Asian cities (Chiang Mai and Ubon Ratchathani in Thailand and Hanoi in Vietnam). Two more models are also being developed in the USA and Brazil. The present version of MARS is implemented in Vensim®, a System Dynamics programming environment. This environment was designed specifically for dynamic problems, and is therefore an ideal tool to model dynamic processes.

MARS is a strategic land use – transport interaction model capable of analysing policy combinations at the city/regional level and assessing their impacts over a 30 year planning period in less than one minute. Figure 1 shows the basic structure of the model. It includes a transport model which simulates the travel behaviour of the population related to their housing and workplace location, a housing development model, a household location choice model, a workplace development model, a workplace location choice model, as well as a fuel consumption and emission model. The sub-models are run iteratively over a 30 year time period. They are linked on the one hand by accessibility as output of the transport model and input into the land use model and on the other hand by the population and workplace distribution as output of the land use model and input into the transport model. A comprehensive description of MARS can be found in Pfaffenbichler (2003) or Pfaffenbichler et al (2008). The model has been transferred to a system dynamics platform VENSIM which provides a transparent approach to model development. The flight simulator approach allows users to change policies and view outputs in a simulation environment with easy to use "slider bars". Outputs are presented in graphical and tabular format with a new link to animated mapping software (Animap). In addition the user may use the VENSIM optimisation facility to optimise a package of policy instruments against a given set of objectives or targets.

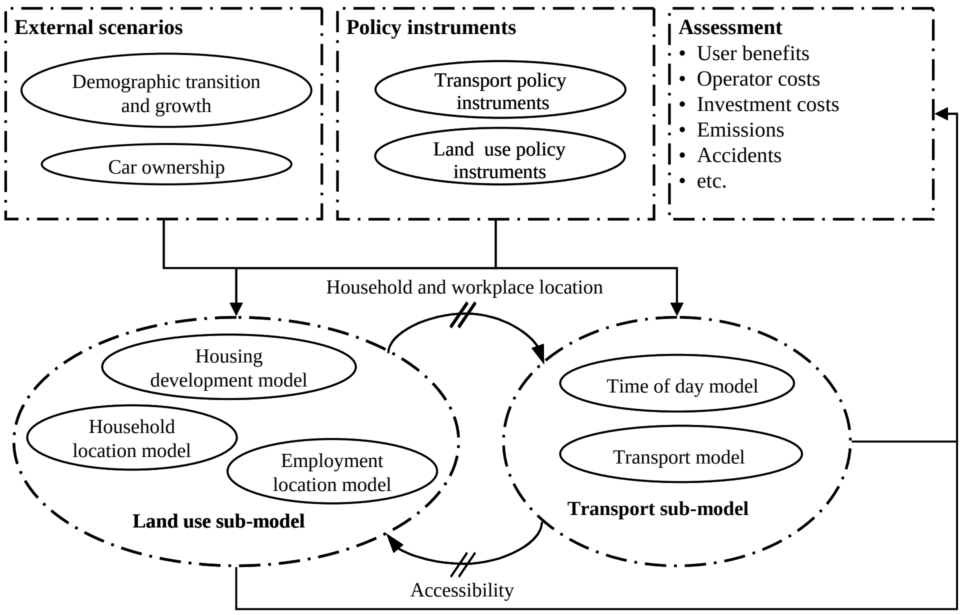

Figure 1: Basic structure of the MARS sub-models

The model is built using the Causal Loop Diagram (CLD) technique to improve transparency. Figure 2 shows the CLD for the factors which affect the number of commute trips taken by car from one zone to another. From Figure 2 we start with loop B1 which is a balancing feedback loop. In it, commute trips by car increase as the attractiveness by car increases which in turn increases the search time for a parking space which then decreases the attractiveness of car use – hence the balancing nature of the loop. Loop B2 represents the effect of congestion – as trips by car increase speeds decrease, times increase and so attractiveness is decreased. Loop B3 show the impact on fuel costs, in our urban case as speeds increase fuel consumption is decreased – again we have a balancing feedback.

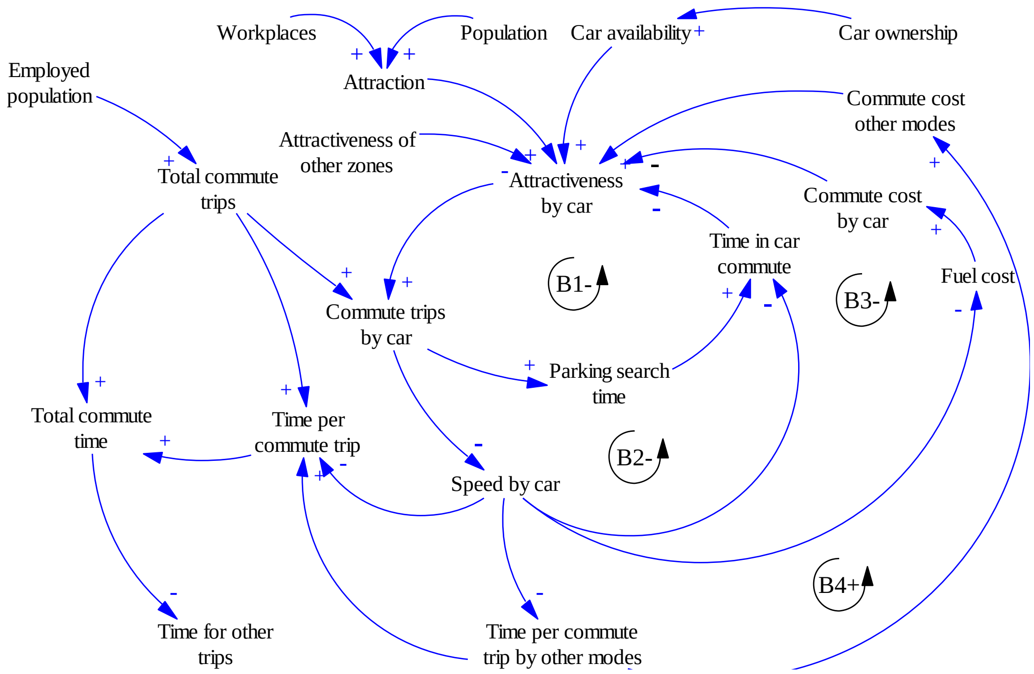

Figure 2: CLD for the transport model – commute trips by car in MARS

Recent enhancements to the model (implemented as part of the DISTILLATE project) include representation of over-crowding, congestion in the off-peak period, representation of a fourth heavy rail mode, the impact of bus quality factors and awareness campaigns. These improvements are reported in Shepherd et al, (2007).

The other major barrier which can be overcome with MARS is that of ease and speed of use and presentation to stakeholders. The model has been transferred to a system dynamics platform VENSIM® which provides a transparent approach to model development.

MARS uses a so called “flight simulator” approach whereby a front-end as shown in Figure 3 is used to control the policy inputs by use of slider bars. This allows the user to test a combination of instruments and to view standard outputs (as shown in Figure 4) within less than one minute. In addition to the standard outputs the user can also animate GIS based data through a specially developed piece of software “Animap” which animates the map based information post simulation (see static view Figure 5). In addition the user may use the VENSIM® optimisation facility to optimise a package of policy instruments against a given set of objectives or targets. Here the user can set bounds on possible instruments, define an objective function or target trajectory for an outcome variable e.g. CO_2 and through the batch run optimisation procedure produce an integrated package which either maximises the objective function or meets the target trajectory.

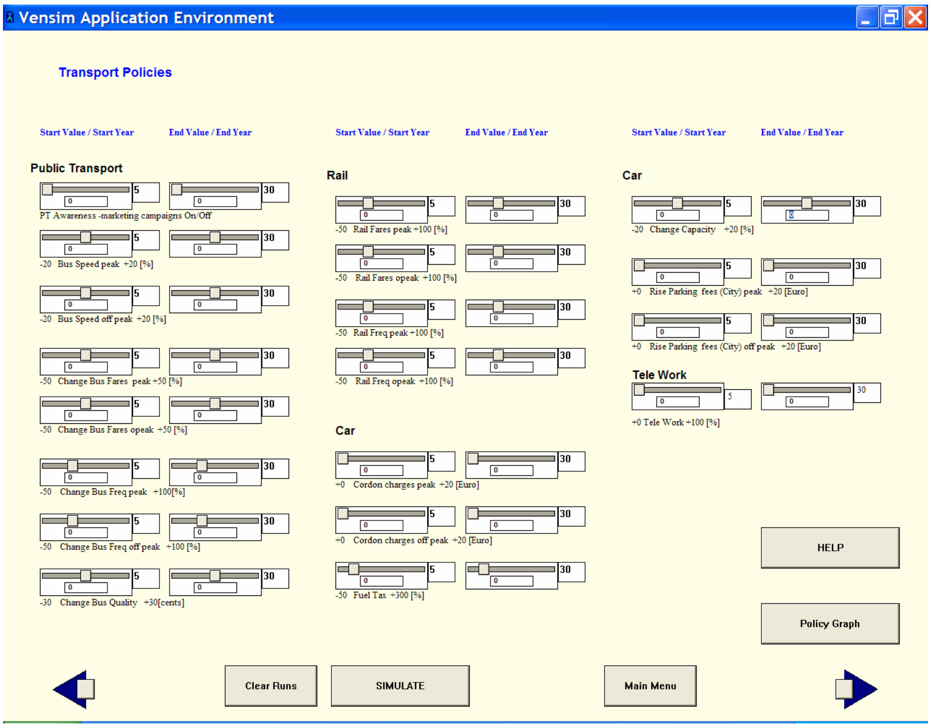

Figure 3 : Example of flight simulator front-end for MARS

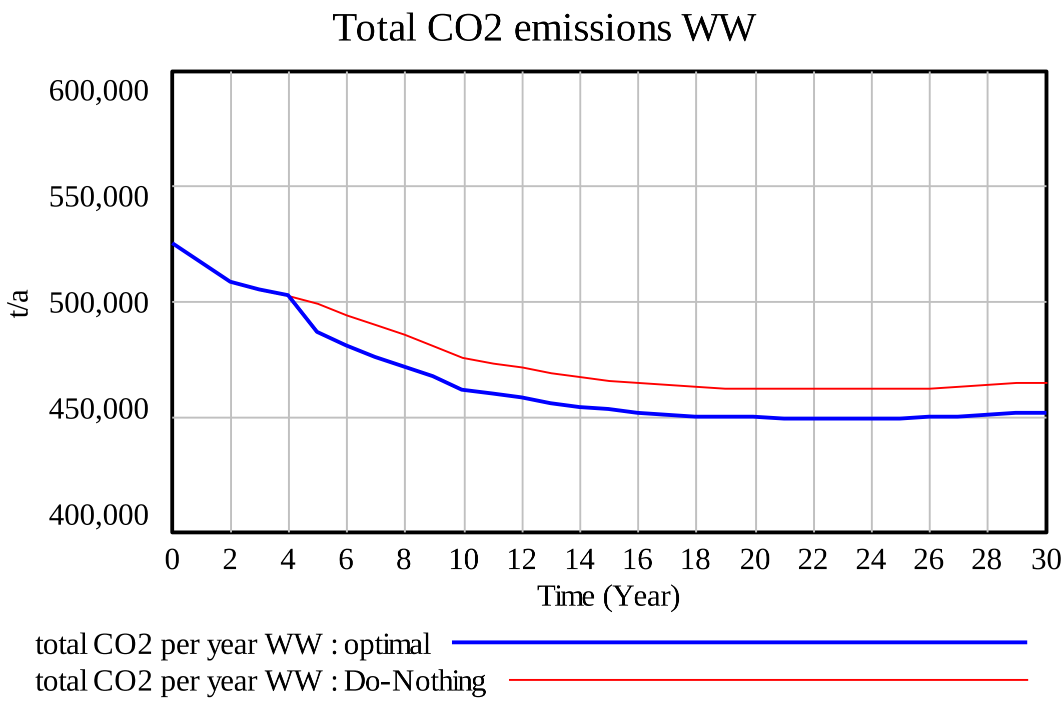

Figure 4 – Example outputs from MARS – CO_2 emissions well to wheel

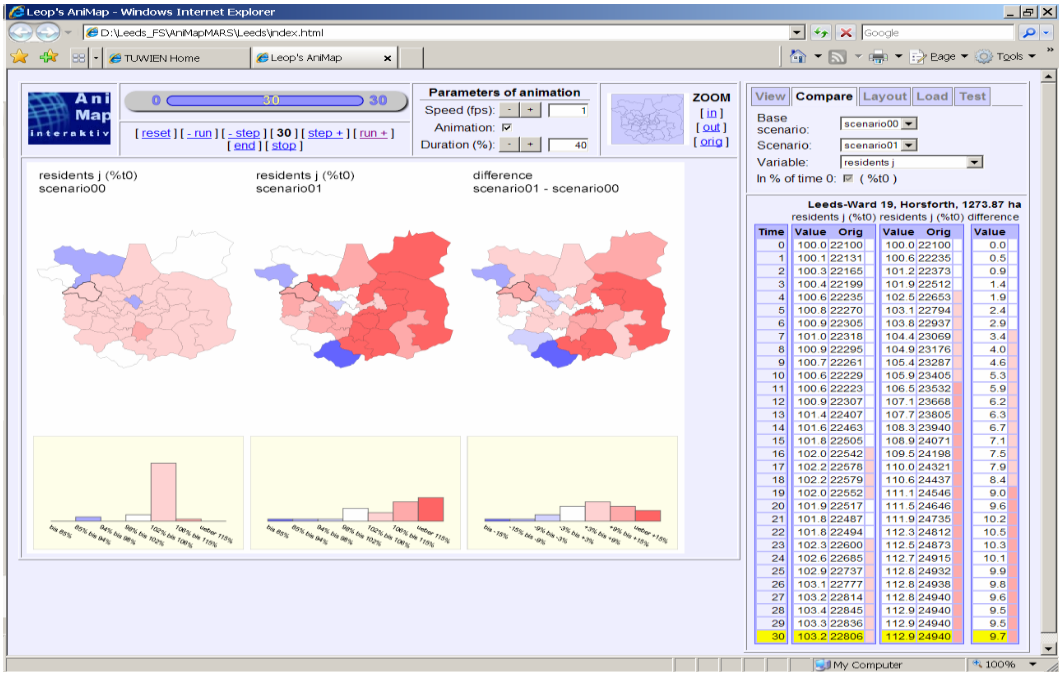

Figure 5: Screen shot from MARS-Animap animation tool.

Model Scope and Zoning

The MARS model is a strategic model and is designed to operate at a highly aggregate level of spatial detail. Most models consist of no more than 50 zones and the zone boundaries are, in the UK models, based on wards to allow population, planning and employment data to be assimilated from existing sources such as census data.

We would expect a MARS model with 50 zones to run on a typical personal computer in less than 2 minutes for a 30-year forecast. This run-time is a key feature of the tool and permits the user to execute a large number of tests and examine sensitivities of forecasts. It also allows users to look at policy instruments alone and in combination to seek possible synergies as was done in a previous study reported in Shepherd et al (2006).

3. LINKING SATURN TO MARS

One of the reasons MARS is a fast model is due to the fact that it does not use a full network and so can skip the assignment stage of the traditional transport modelling process. Whilst this has obvious advantages in terms of run times when predicting impacts over a 30 year period, the drawback from a client perspective is in having credible baseline speeds. The aim of the link between SATURN and MARS was to provide a set of inputs which (a) formed the basis for speeds between each OD pair in the base year (b) to provide specific speed flow relationships for each OD pair for use in future year forecasts and (c) to provide growth factors back to the SATURN model which represent different land use and policy scenarios undertaken in MARS.

The process reported in full in Koh and Shepherd (2009) involves the following steps:-

1. Mapping of SATURN zones to MARS aggregate zones
2. Running SATURN to collect speed flow data and aggregate/compress
3. Estimation of speed flow relationships per aggregate OD pair
4. Incorporation of relationships within a revised MARS model
5. Comparison of base year matrices with census data
6. Passing back growth/policy factors for future years to SATURN

The first step using Leeds as an example involves mapping the 538 SATURN zones onto the 33 MARS zones depicted in figure 6. Next SATURN is run with a range of demand factors applied to the matrix and the compression process provided by SATURN is used to aggregate data from the detailed zoning system to the 33*33 matrix associated with the MARS zone to zone movements.

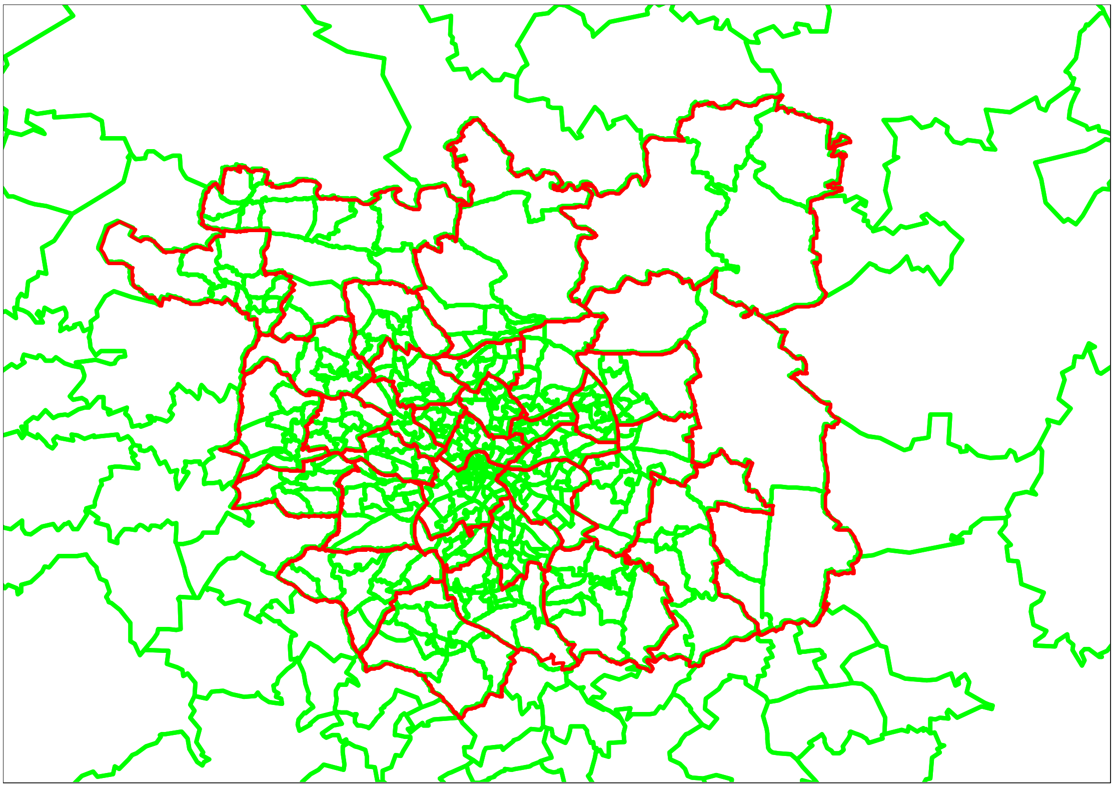

Figure 6 MARS Zoning System (red) superimposed on the SATURN zoning system (green)

The speed-flow relationships were "fitted" through the general speed-flow relationship for each origin-destination pair. In MARS the speed-flow relationship used is that by Singh (1999) and is of the following form:-

$$V_{ij}(t) = \frac{V_{ij}^{f}}{1+\alpha(DF_{ij}(t))^{\beta}} \qquad 3.1$$

where

$V_{iJ}(t)$ is speed in km/h between origin i and destination j at time t

V^{f}_{iJ} is free-flow speed (km/h) between origin i and destination j

α,β are parameters taken as 0.15 and 4 respectively (Based on data from 1964 Highway Capacity Manual) in previous versions of MARS for all OD pairs

$DF_{iJ}(t)$ is the demand factor between origin i and destination j at time t

The demand factor is defined further as follows :-

$$DF_{ij}(t) = DF_{ij}(0)\left(\frac{T_{ij}(t)}{T_{ij}(0)}\right) \qquad 3.2$$

Where $DF_{ij}(0)$ is the demand factor in the base case and $T_{ij}(t)$ and $T_{ij}(0)$ are the demand in trips at time t and time zero respectively. The initial demand factor $DF_{ij}(0)$ is calibrated to the initial average speed $V_{ij}(0)$ and the free-flow speed as follows :-

$$DF_{ij}(0) = \sqrt[\beta]{\frac{V_{ij}^{f} - V_{ij}(0)}{\alpha V_{ij}(0)}} \qquad 3.3$$

The aim of the SATURN-MARS link is to ensure (a) that the speeds at time zero (base year) and free flow speeds are compatible per OD pair and (b) that the relationship has the best fit through the other levels of demand. This best fit can be achieved by varying the parameter β for each origin-destination pair whilst minimising the least square of the differences between the observed and estimated data.

Figure 7 gives an example of the speed-flow data and relationship fit through the data for MARS zone 1 to 20.

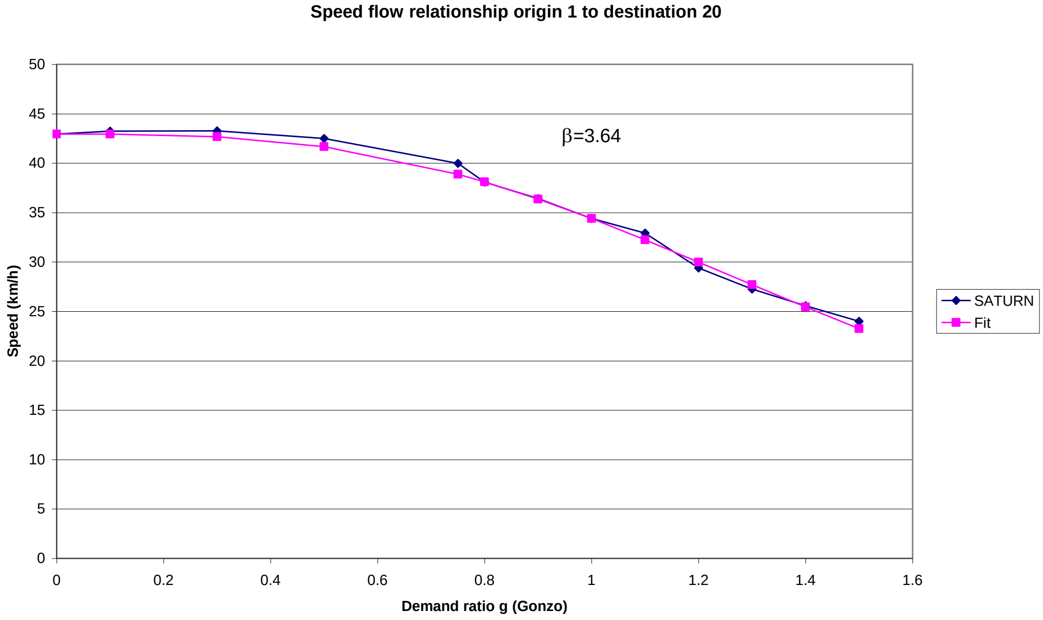

Figure 7 Speed flow example fit – zone 1-20

Note that the fitting process guarantees the fit for demand factors 0 and 1.0 which correspond to the free-flow speed and current speed from SATURN in the base year. With this process the form of the speed flow relationships is as in 3.1 with β_{iJ} rather than β as we now have OD specific relationships which were then implemented in the MARS model structure.

Once the speed flow relationships were implemented, the MARS model was re-run for the "Do-nothing" for the 30 year planning period. To fully test whether the speed flow relationships are proving useful for future forecasts of congestion per OD pair in MARS the following test was devised. Firstly the growth factors per OD pair in MARS at t=30 (year 30) were output to a CSV file. These factors $g_{ij} = \left(\frac{T_{ij}(30)}{T_{ij}(0)}\right)$ were taken directly from the MARS model and then dis-aggregated using the reverse of the compression process to form a new SATURN matrix. The growth factors ranged from 0.62 to 3.5 with a mean of 1.22 – implying total growth in car trips of 22% over 30 years. The external zones were also factored up with an average growth rate of 22% in the SATURN model.

The new SATURN matrix for year 30 was run through the original SATURN network and the aggregation process was then repeated to obtain the new average speeds at the MARS OD level. These were then compared to those reported in MARS. Figure 8 shows the comparison of speeds for year 30 between MARS and SATURN. In summary this task has provided an automated procedure for aggregating base year speeds and speed-flow relationships from the SATURN zoning system to the MARS zoning system. It ensures compatibility between base year speeds and to some extent future year speeds. The feedback of growth factors allows for land use and policy aspects to be taken into account when generating future year matrices in SATURN.

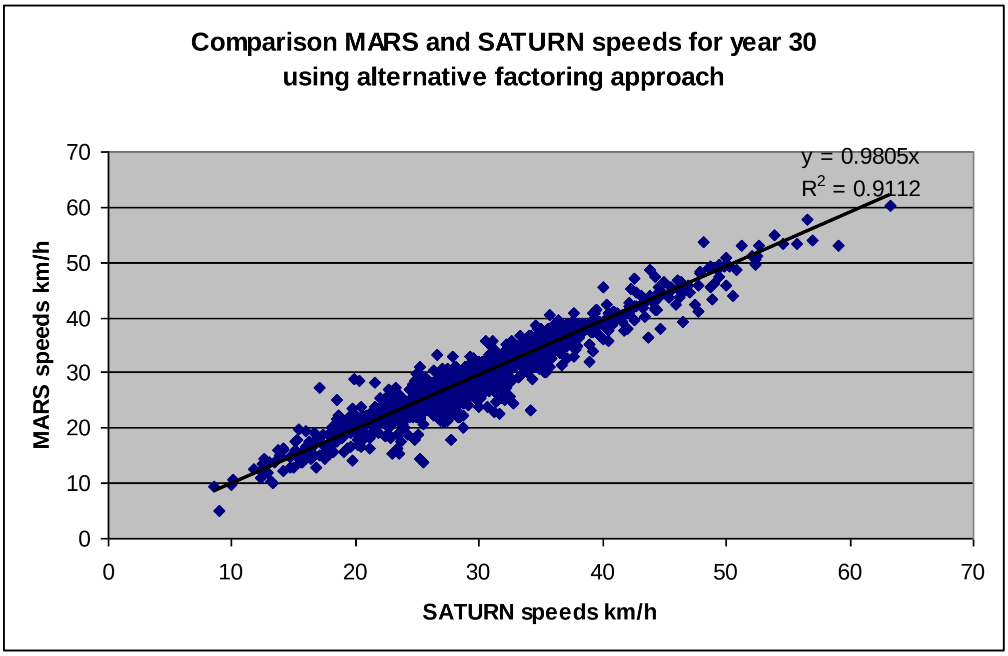

Figure 8: Comparison of speeds in year 30 using alternative factoring approach

4. ENHANCING THE OPTIMISATION AND STRATEGIC APPRAISAL CAPABILITIES OF MARS

The aim of this task was to enhance the outputs within MARS to be able to automate a multi-criteria analysis (MCA) for use in the strategic appraisal of policy and land use options. As MARS is a fast running model this approach along with the easy to use flight simulator then allows users to generate and filter out many options within a reasonable amount of time (and budget). MARS also has the advantage of being able to be run in batch mode linked to an optimisation facility which will then output the “optimal” integrated strategy measured against the given MCA or target setting criteria.

The main part of the task was to implement and connect indicators within an MCA framework which reflected the TaSTS challenges or goals set out by DfT. The MCA normalises indicators between user defined worst and preferred values and sums the indicators according to user defined weightings. Each indicator has therefore a score between 0-100 with 100 being the best possible score, these indicators are recorded over the planning period and the resulting weighted MCA also has a range from 0-100 with 100 being the better outcome. The agreed indicators and the implementation view in VENSIM are shown in table 1 and figure 9 respectively.

Table 1: Mapping of MARS indicators on TaSTS Challenges

TaSTS Challenge	MARS Indicator	Comments
Climate Change	Annual CO2 emissions	Supports the TaSTS goal of reducing the CO2 and other greenhouse gases to avoid climate change
Competitiveness and productivity	Average delay in person hours (car peak)	Align well with the TaSTS objective of sustaining high level of GDP growth by maximising the competitiveness and productivity
	Economic vitality index of target zones	
Equality of opportunity	Accessibility of key services (all modes)	The DfT's equality of opportunity goal is to promote greater equality of transport opportunity for all citizens, with the desired outcome of achieving a fairer society.
	Non-car accessibility of low income zones	
Health, safety and security	Number of accidents	Supporting the goal of contributing to better health and longer life expectancy
Quality of Life and Natural Environment	Annual NOx + PM10 emissions	Measures the effectiveness of quality of life both for transport and non-transport users
	Change in area classified as urban	

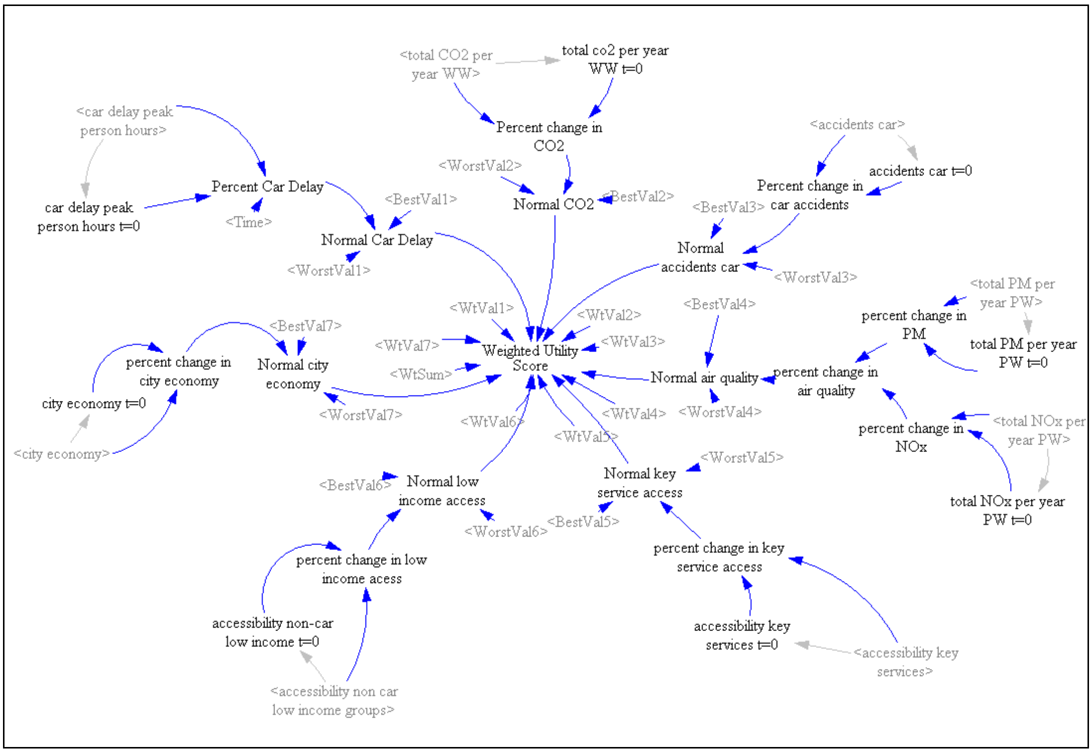

Figure 9: MCA View in MARS

To illustrate the process, a Do-nothing scenario and a test scenario were simulated in MARS. Do-nothing scenario does not involve specifying any policy inputs, except the default values such as the number of years of model run (which is currently set to 30 years).

A two pronged strategy involving public transport and private vehicles has been implemented to demonstrate the MCA. Public transport fares are reduced by 35% both in peak and off-peak. Bus frequencies are increased 10% in peak and 35% in the off-peak. Finally we impose a 10% reduction in car parking space within the study area (this is a large reduction but serves to illustrate the MCA).

A Do-nothing scenario and the test scenario were simulated over a period of 30 years and Figure 10 shows the results for all indicators and weighted MCA view. This specially constructed view is available immediately to the user and allows them to compare strategies at the aggregate level. Further standard outputs are available and it is always advisable to look down into the detail to fully understand the impacts of a strategy.

The outcome of the example test is to improve almost all indicators. Firstly, the congestion level is expected to reduce with the car delay scoring over 45 compared to 34 in the Do-nothing. Safety also improves though the trend of decline is not reversed. Accessibility to key services and that by the low income areas has been predicted to improve over the Do-nothing scenario. CO_2 emissions are expected to reduce if the strategies are adopted and even the quality of life as measured by PM and NOx is likely to improve over the Do-nothing scenario. The city economy indicator remains unaffected in both the scenarios which suggests that this indicator is perhaps affected only by significant land use changes. Finally, the overall weighted score increases over the whole period. Whilst this demonstrates the changes in MCA for one particular test a user would then proceed to try out other strategies and compare. We would also expect that the user would wish to “dig down” to understand the causes of change in some indicators – for example the change in CO_2 will be made up from changes in both the peak and off-peak and from car use as well as public transport use.

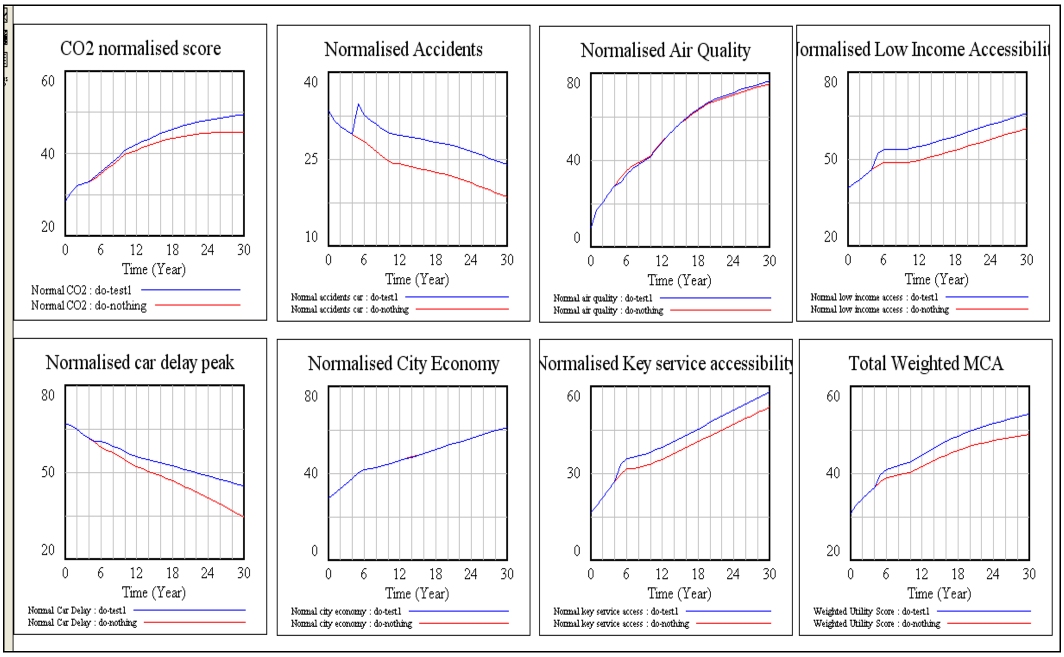

Figure 10: Normalised Values of MARS indicators for test example

Value for Money (VfM) – Cost of Reducing CO2

Although some alternative instruments (more specifically, some combinations of instruments) may be effective in reducing CO2 emissions, they may be far more expensive than other alternatives. Hence, we need an indicator to identify the alternatives which promise the best return or value for money spent. Traditional CBA approaches require setting up a structure for discounting the costs/benefits over the period of analysis. With an intention to avoid setting up a structure similar to a full CBA, we have selected a simple approach to look at the cost of reducing CO2. This approach involves comparing the amount of money spent per tonne of CO2 reduced over the Do-nothing alternative – the lower the money spent per tonne reduction, the higher the value for money. This is a simple indicator which is obtained by summing the cost of implementing the instruments of an alternative plan and then dividing it by the expected reduction in CO2 over the Do-nothing alternative. Numerically, it is computed as follows (implemented for example policies of bus frequencies, road capacity changes, parking places and road user charging):

$$Money\ spent\ /\ tonne\ of\ CO_2\ reduced = \frac{(Bus\ Frequency * Cost + Road\ Capacity * Cost + Parking\ Places * Cost + Cost\ of\ Road\ User\ Charge)}{Do\ nothing\ CO_2 - Test\ CO_2}$$

It is important to note that the indicator can take negative values when the test CO2 increases over the Do-nothing alternative, which is obviously not an ideal alternative. Computing the indicator requires the unit costs of implementing various instruments such as road capacity, bus frequency changes, parking provision/reduction etc.

However, cost of some instruments such as road user charging is just added to the total cost depending whether it becomes a part of the policy or not. As part of this task, we have developed an input structure for entering unit costs which have for now been populated with purely notional values. The notional costs of the instruments are implemented as ‘Cost per year per % change of the instrument’, with the exception of road user charging which is represented as ‘cost per year’. Figure 11 indicates notional unit values of adding various elements to the transport system. These notional values need to reflect relative costs of implementing various instruments. For example, adding to the road capacity is much more expensive than adding to the public bus frequencies. Similarly, operating extra buses could be more expensive during peak hour than the off-peak. However, implementing a road user charge during peak and off-peak hours may not be different from each other although the charge that the users pay may differ. When setting up a MARS model for any city, the notional costs should be replaced with real estimates of implementing various instruments being proposed.

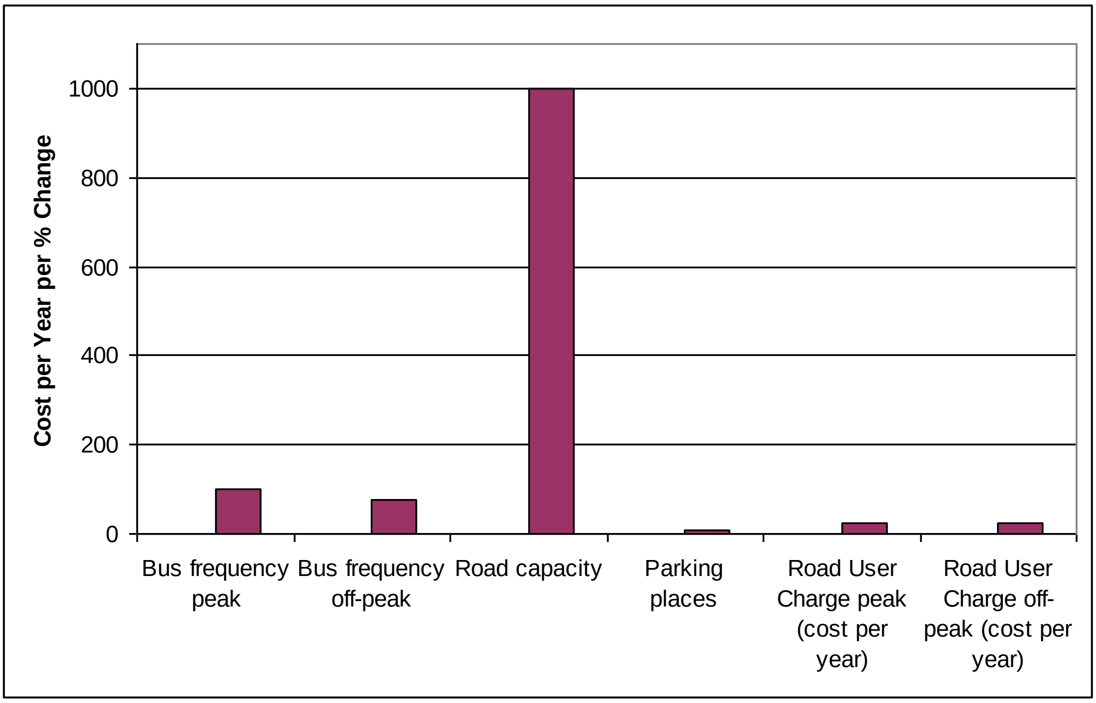

Figure 11: Notional Unit Costs

To illustrate the VfM indicator, consider two test cases – the first case is a car oriented one, envisaging an increase of road capacity by 3% and an extra 10% of parking spaces. The second case is identical to the two pronged public transport oriented strategy described in § 5.2. Both the test cases were simulated and Figure 12 shows the amount of CO2 reduced in each test case. Car oriented test 1 results in much lower reductions in CO2 compared to the public transport oriented test 2. In addition, test 2 involves schemes which are less capital intensive in nature, and hence, promises a higher return in terms of money spent per tonne of CO2 reduced (Figure 13).

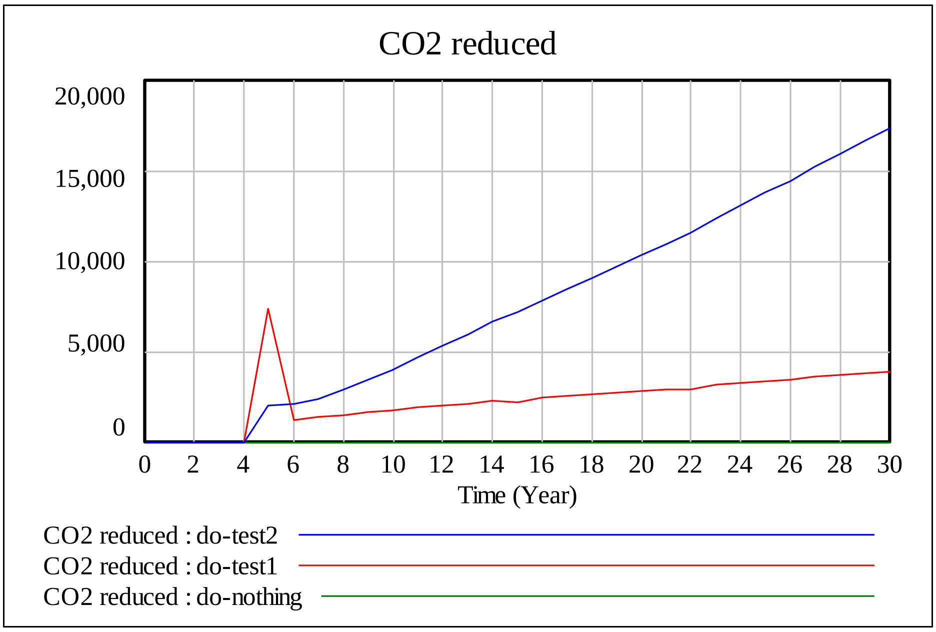

Figure 12: Reduction in CO2 (tonnes/year)

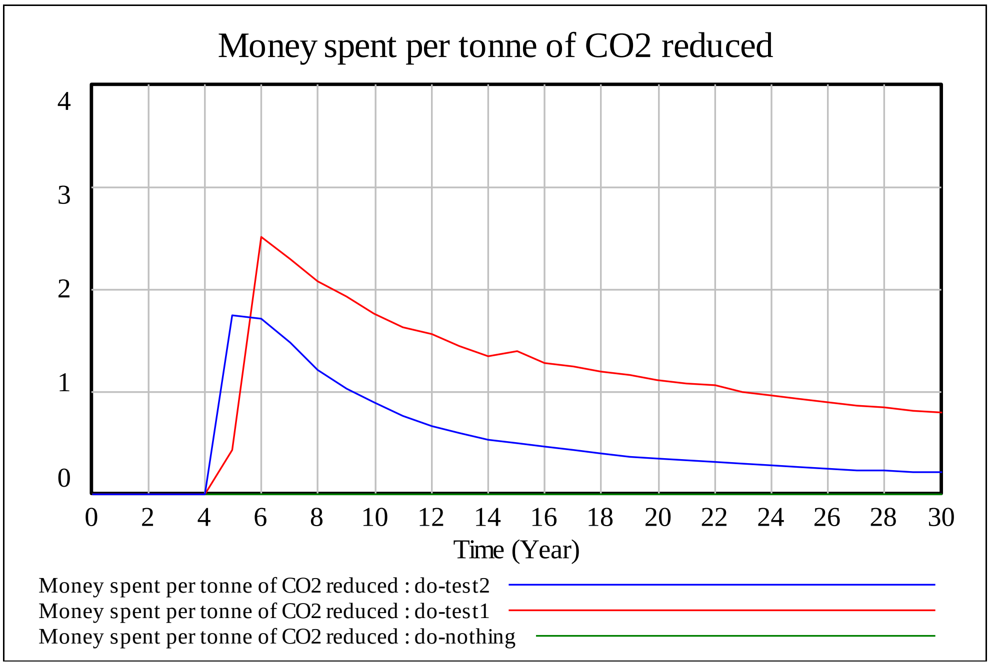

Figure 13: Value for Money

Figure 13 shows that the value for money indicator favours the second strategy which involves public transport fare reductions and frequency increases over the car based policy. We believe that this value for money indicator may be a useful indicator to use in addition to the MCA, however we are aware that it may require further work to include impacts of revenues and taxes collected.

Optimisation example

This section continues with the above strategy examples but uses the optimisation facilities within VENSIM to find the optimal combination of instruments within a given set of bounds. The idea is to maximise the MCA score by varying the instruments within the given bounds.

The policies within MARS are defined as policy profiles with the level of each instrument being defined at the short term year (default year 5) and the long term year (default year 30), values are then linearly interpolated between these short and long term levels. This means that there are two variables to define for each instrument considered in the optimisation problem.

Continuing with the examples from test 1 and test 2 above we define the bounds on the instruments as shown in table 2. Note that we do not consider reductions in bus frequencies or road capacity but do allow the number of parking places to increase or decrease by a maximum of 10%. Fare reductions are also limited to 50%. These bounds are the same for both the short term and long term years though in theory these can differ.

Table 2 : Upper and lower bounds for short and long term years

Instrument	Lower bound	Upper bound
Fares Peak	-50%	+50%
Fares Off-Peak	-50%	+50%
Bus Frequency Peak	0%	+100%
Bus Frequency Off Peak	0%	+100%
Road Capacity	0%	+20%
Number of Parking places	-10%	+10%

Initial tests with the above problem using the weighted MCA score as the objective function resulted in policies where all instruments were driven to either an upper or lower bound. This was (we think) due to the fact that the MCA score is in general adding fairly linear indicators (or differences in indicators). It was seen that for a given instrument, if a 1% increase in its value increased the MCA score overall then all further increases also increase the MCA score – even if at a lower rate. Hence in this case the optimal value would lie on the upper bound. A similar argument would result for decreases. Whether or not an instrument should be increased or decreased also depends heavily on the assumed weights and assumed best and worst values which control the normalisation of indicators. Whilst this may help in determining the direction in which to move a given policy instrument it does not aid in finding an optimal combination.

To get around this problem we developed another cost indicator which was missing from the overall MCA. As the approach should be simple and in order to integrate it with the MCA we chose not to calculate the full CBA or benefit cost ratio. Instead we developed a cost indicator which can be normalised between 0 and 100 as follows :-

$$Cost\_indicator = 100 * \left(\frac{\max budget - schemeCost}{\max budget} \right)^{1/4}$$

With the above indicator the user can set a maximum budget for all schemes. If scheme costs are zero then the indicator scores 100 and this happens in the do-nothing case. As the scheme costs are increased then the indicator will reduce to zero. The power function is used so that the indicator reduces more quickly as the maximum budget is approached. With this normalised indicator for scheme costs we can add it to the weighted MCA score as we would any other indicator.

Applying this within the previous MCA score and solving for the instruments used in test 1 and test 2 with bounds as in table 2 and costs per percentage change as previously the optimisation process finds the solution to be as shown in table 3. Peak frequencies and changes in road capacity are not cost effective and are therefore unchanged. Parking places are reduced to their lower bound as are fares. It should be noted that we have not included the reduction in fare revenue within the cost indicator but this could in theory be included (which would then result in lower fare reductions). The only interior solution is for off peak frequency changes which are cost effective up to increases of around 80%. Higher frequencies cause a lower cost indicator which results in a lower overall score. Figure 14 shows the MCA indicators from this optimal strategy. Whilst accidents, car delays and accessibility measures are seen to improve significantly the impact on CO_2 and air quality is detrimental compared to the do-nothing case. This is only a demonstration of the approach and the weights used were equal in this case. Other weights and assumptions on best and worst values would give different results and these should be seen as a demonstration of the approach only. Other objectives can also be used in the optimisation process in a similar manner, for example it is possible to find the combination of strategies which meet some CO_2 target trajectory or to include some other local targets within a multi-objective approach.

Table 3 : Upper and lower bounds for short and long term years

Instrument	Year 5 value	Year 30 value
Fares Peak	-50%	-50%
Fares Off-Peak	-50%	-50%
Bus Frequency Peak	0%	0%
Bus Frequency Off Peak	81.2%	84.6%
Road Capacity	0%	0%
Number of Parking places	-10%	-10%

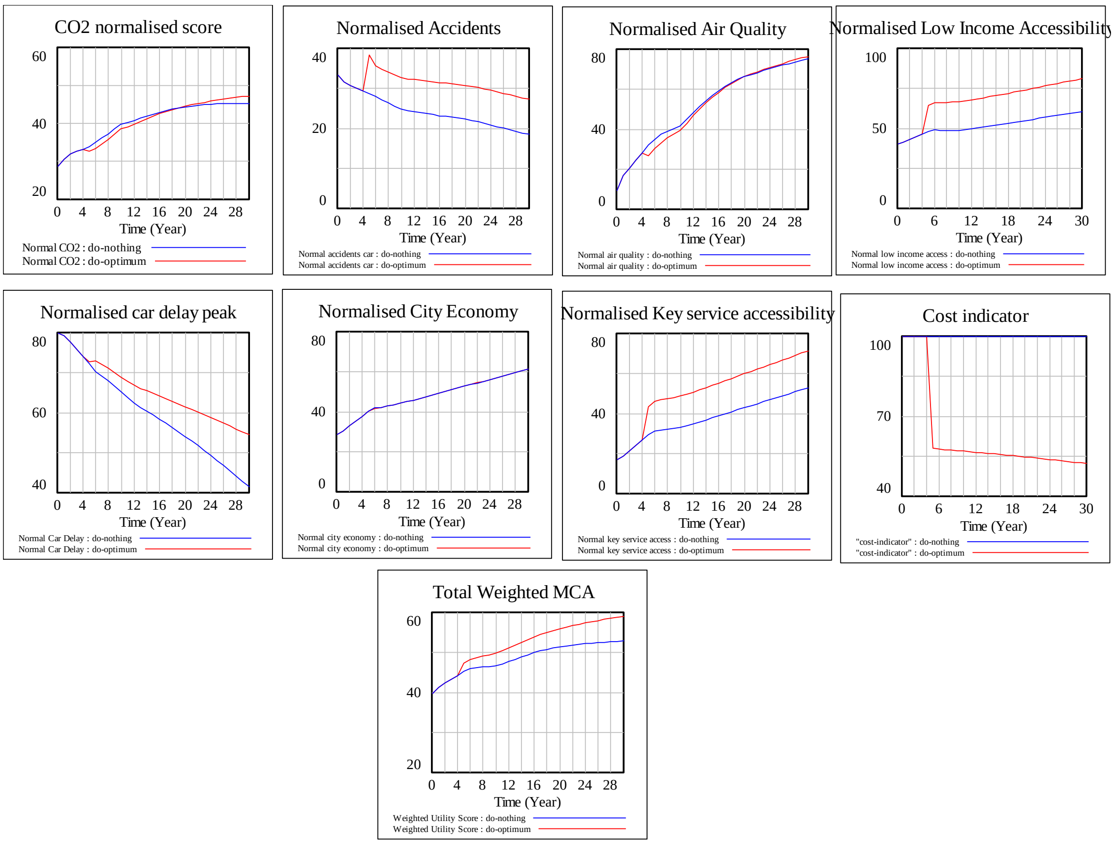

Figure 14: MCA outputs comparing optimal and do-nothing solutions

5. IMPROVING SPATIAL POLICY INPUTS

Previously, policy instruments in the MARS model were usually assumed to be applied throughout a city (e.g. fares policies) or within the city centre (e.g. cordon charges). However, some policy instruments such as bus rapid transit are more appropriately applied to corridors. The aim of this task was to enable corridor movements to be identified and appropriate policy instruments to be applied selectively to them. At the same time, all policy inputs would be restructured into one policy file so that future models are easier to maintain.

The process involved the following steps and these are reported in full to the DfT in Pfaffenbichler and Shepherd, (2009) :-

1. Definition of a common notation

2. Separating the policy instrument definition from the core model

3. Creating a new policy user interface

4. Creating a new Excel® data file for the definition of policy instruments

5. Demonstrating the new policy instrument definitions using a simple case study

Policies in MARS are defined by changes in policy instrument profiles over time. The profile is set in a short term year and a long term year which can now be defined by the user (default values are also given as year 5 and year 30). The policy level in between the short and long term year is found by linear interpolation.

Rather than detail the whole process we concentrate on the process to define bus strategies. Figure15 shows the user interface for defining the bus related policy instrument values. For the instruments bus fares and bus frequencies these values are percentage changes. The bus quality factor is measured in money terms (i.e. Euro cents). In addition to that the user has now the option to decide whether the instruments are applied uniformly in the whole case study area or only in a pre-defined corridor. To do so the users have to set the slider "*Uniform (0) or corridor (1)*" either 0 for uniform or 1 for corridor. The default value is 0. For the definition of the corridors the user has to input which origin-destination pairs are affected using simple spreadsheet inputs (see section **Error! Reference source not found.** in full report).

The policy instruments "*Bus awareness campaign*", "*Bus lanes peak*" and "*Bus lanes off peak*" can only be turned on and off by the user. The instrument "*Bus awareness campaign*" is currently applied uniformly to the case study area while the instruments "*Bus lanes peak*" and "*Bus lanes off peak*" necessarily have a spatial dimension.

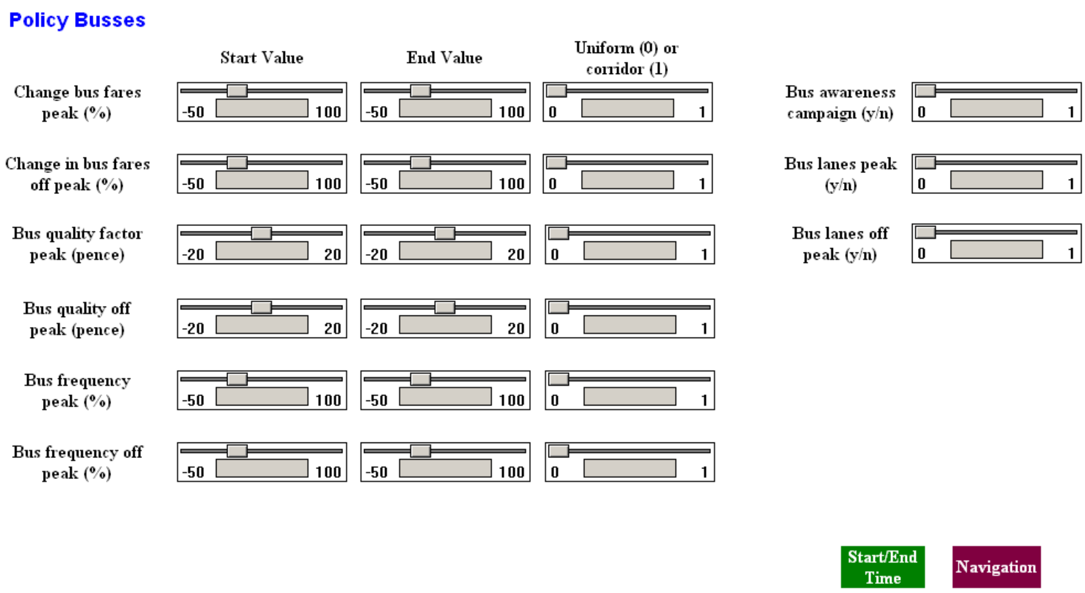

Figure 15: View "Policy User Interface Bus" MARS version 13

In an example to demonstrate the new features for the policy instrument definition we approximated the Leeds Trolley Bus scheme[2] (www.ngtmetro.com/About/, www.insideyorks.co.uk/tbus/index.html). It was assumed that the zones City and Holbeck, Kirkstall, Headingley, University, Hunslet, Weetwood, Rothwell and Cookridge are affected by the bus scheme modelled with MARS (Figure 16). All instruments are defined to be applied in the corridors defined by the aforementioned zones. The start and end years are arbitrarily set at 5 and 30 years respectively for all instruments.

[2] It should be noted that all assumptions are our own and used here merely to display the new functionality of the model. Leeds City Council or METRO have not been involved in this application and the results are by no means intended to be used to assess the scheme proper.

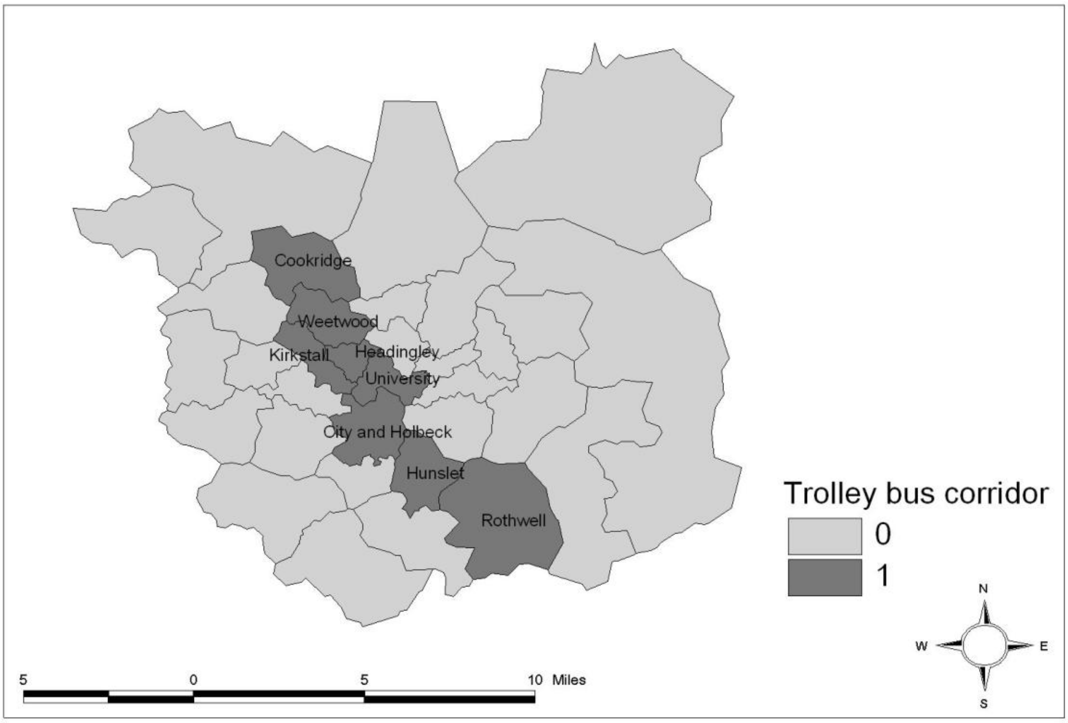

Figure 16: Definition Leeds trolley bus scheme

Bus lanes are assumed to be effective during peak and off peak periods on 10% to 50% of the bus network in the corridor. It is assumed that the bus scheme is of high quality and hence results in a positive effect worth a fare rebate of 20 Euro cents in both the peak and the off peak periods. It is assumed that the bus lanes reduce the circulation time to such an extent that a 25% increase in frequency is possible without additional operation costs. It is also assumed that in the corridor the bus lanes reduce the road capacity for private cars by 20 % and the number of on street parking places by 10 %. (Note these assumptions are used to demonstrate the model functionality and would need to be assessed with a client in a real case study). Similar easy to use sliders are implemented for car policies and set for this test as shown in figure 17.

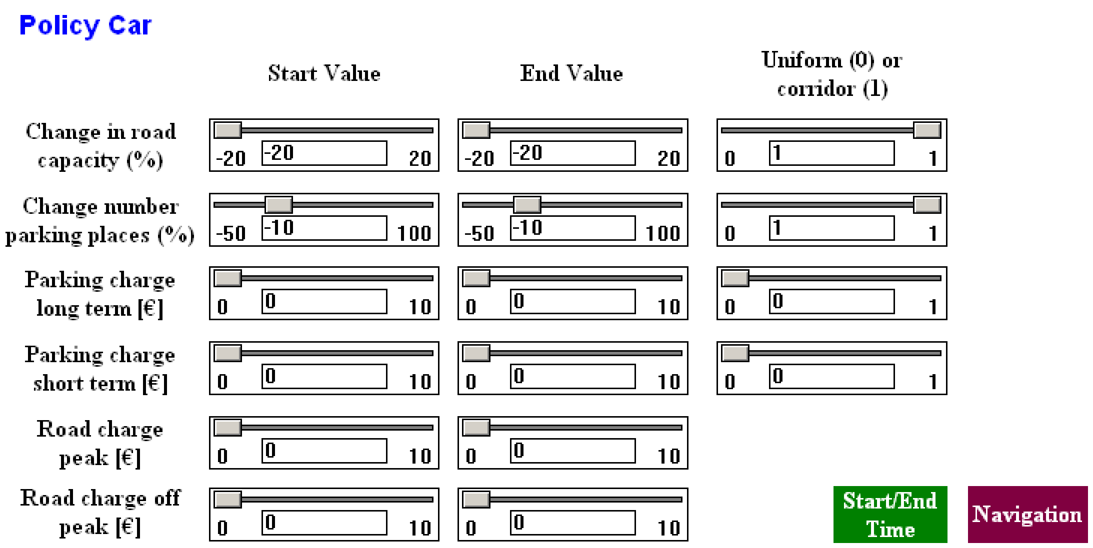

Figure 17: Policy instrument settings view "Policy User Interface Car"

The results may be viewed using the previous MCA type indactors but in this case it is also worth presenting the animap GIS facility. Figure 18 shows one possible view from animap giving the change in mode split for bus by origin in year 30 relative to year 0 comparing between do-nothing and the Trolley bus scheme.

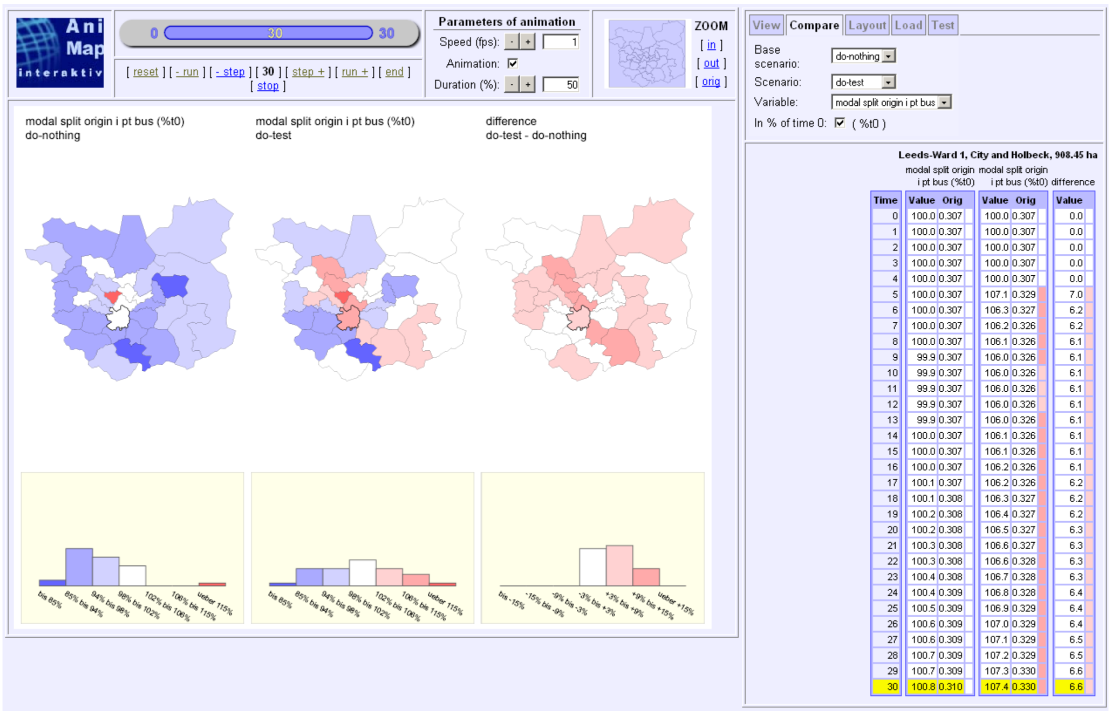

Figure 18: Mode split bus measured as year 30 relative to year 0, comparison of a scenario do –nothing and scenario do-test

The blue colour indicates a decrease over time while red indicates an increase over time. Furthermore a histogram of the zone wise results is inserted below each section of the screen showing the maps. Above the map the user can navigate through time and zoom in and out of the map. Clicking on a zone in the map displays the results of the zone in tabular form in the right part of the screen. Up to three different indicators can be shown in parallel.

The results above demonstrate how the mode share by bus increases mainly in the corridor where the scheme is applied but also to a lesser extent in other zones. This is due to the interaction of the car based measures with other zonal movements such as the reduction in capacity and parking spaces along the corridor which is used by other movements. Further outputs and description of results are presented in the full report (see Pfaffenbichler and Shepherd, 2009).

6. SUMMARY

This paper summarises the work undertaken for the DfT as part of a follow-up to the DISTILLATE project. More specifically it reports on the enhancements made to the strategic model MARS. The model has been modified so that it now has an easy to use link with SATURN providing compatible base year speeds, Origin Destination specific speed-flow relationships taken from SATURN and incorporated within the MARS structure and the capability to feedback future growth factors to the SATURN model. These growth factors could be representative of multi-modal transport and land use policies at the strategic level.

Secondly the model has been improved to produce an automated multi-criteria analysis where the indicators used are now in line with DfT's TASTS challenges. Immediately accessible output is provided in graphical form showing how these indicators vary with policy over the 30 year planning period. It is also possible to use the VENSIM optimisation facility to obtain an integrated policy or strategy which maximises some user defined objective such as the weighted MCA although it is also possible to find a trajectory of policies which can meet given CO_2 targets.

Finally the user interface with MARS has been enhanced to standardise the input of spatially varying policy instruments such as an investment in a bus corridor. The enhancements were demonstrated by developing a simple example for the Leeds Trolley bus scheme. Here the graphical system "animap" was used to present spatial changes in mode split by origin over the planning period.

Future work could include the implementation of a full cost benefit analysis at the strategic level or a link between the core model within MARS and the option generator being developed as part of KonSULT – see the companion paper by May et al (2010).

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